The Evolution of the World Income Distribution*

BY KEITH SILL

There is tremendous disparity in the levels of individuals' incomes across countries. However, this disparity in per capita income has not always existed. In this article, Keith Sill investigates some facts about the evolution of per capita income across countries and reviews a simple model that broadly captures the observed evolution of the world income distribution since 1800. He then discusses what predictions can be made about future cross-country distributions of income and some policy prescriptions that follow from our understanding of the past and our predictions about the future.

There is tremendous disparity in the levels of individuals' incomes across countries. Those fortunate enough to live in the richest countries have an average income that is about 30 times greater than the average income of residents of the world's poorest countries. Such a large disparity in income across countries implies large differences in living standards and well-being. A significant share of the world's population has a living standard well below that of the average U.S. citizen. Indeed, inhabitants of the world's poorest countries face daily hardships and deprivations that are so foreign to the citizens of rich countries as to be hard to believe.

However, this large difference in per capita income across countries has not always existed. It wasn't until the early 19th century that countries began to experience significantly different growth rates in income as some countries were quicker to begin the process of industrialization. Conse- quently, before the late 1800s, there was relatively little income disparity across countries, at least by today's standards. But it doesn't take long for small differences in income growth rates to lead to wide divergence in per capita income levels. From the late 1800s until about the 1960s, there was a steady and rapid increase in inequal- ity. Since then, the cross-country dispersion in per capita income has become somewhat more stable, while, at the same time, world poverty has been decreasing as countries with large populations, like China and India, begin to industrialize.

We'll investigate some facts about the evolution of per capita income across countries and review a simple model that broadly captures the ob- served evolution of the world income distribution since 1800. Given our analysis of what happened in the past, we'll discuss what predictions can be made about future cross-country dis- tributions of income. We'll also discuss some policy prescriptions that follow from our understanding of the past and our predictions about the future.

EVOLUTION OF COUNTRY PER CAPITA INCOMES BEFORE 1800

Before 1800 and the onset of the Industrial Revolution, the distribution of world income looked very different than it does today. While cross-coun- try data on incomes and population prior to 1800 are incomplete and chal- lenging to piece together, the avail- able information suggests that there was little, if any, growth in per capita incomes in any of the world's econo- mies. Before the Industrial Revolu-

Keith Sill is an economic advisor and economist in the Research Department of the Philadelphia Fed. This article is available free of charge at www.philadelphiafed.org/econ/br/.

tion, economies were agricultural, and living standards were similar across countries and over time. People born before 1800 could expect to be about as well off as their parents, grandparents, and great-grandparents. In addition, they could expect their children to be about as well off as they were. Moving to a different country wouldn't have improved living standards much either — the agricultural technology across countries was about the same. This stands in stark contrast to today's world, in which living standards have increased rather consistently over time (at least in the developed countries) and vary greatly between poor and rich countries.

We will measure the standard of living, or economic well-being, of the typical resident of a country using real gross domestic product (GDP) per capita, which is real GDP divided by a measure of the population. Real GDP is all of the goods and services produced domestically by residents of a country. Higher real GDP means that a country produces more goods and services for its residents to consume and invest in. By itself, real GDP is not a particularly good measure of how rich a country is because a country with a large population is likely to produce more than a country with a small population. When we divide a country's real GDP by its population, we get a measure of goods and services produced per person: Rich countries will produce more per person than poor countries.

However, real GDP per capita is not an all-inclusive measure of a country's well-being. Factors that affect well-being include leisure time, income sharing within households, environmental quality, and health. These factors may be imperfectly correlated with output per person, and there is some evidence from survey data that the correlation between output per

capita and happiness is weak across OECD countries.[1] Despite these potential problems, we will treat real GDP per capita as a useful summary measure of well-being for purposes of cross-country comparison. After all, it seems implausible to argue that in some broad sense Africa's poorest residents are as well-off as the residents of the U.S.

Unfortunately, official statistics on GDP for most countries start after World War II. So how do we measure the world income distribution far back

in history? Recent work by Angus Maddison, the eminent economic historian, pieces together various bits of evidence to develop measures of real GDP per capita for several regions of the world going back to 1 AD. Going that far back in time means that there is considerable uncertainty about particular measures of living standards, since the recorded evidence on how people lived is sparse. However, over that time span, virtually all societies were traditional agricultural societies, and agricultural technology seems not to have varied greatly across countries. Furthermore, we could hypothesize

that average living standards before 1800 were probably similar to the living standards of today's poorest countries, which are agricultural societies that do not have much capital or technology to work with.

Figure 1 plots some of the per capita income data from Maddison's study for several regions of the world from 1 AD to 1820.[2] The figure shows that even the fastest growing regions of the world, which are denoted Western Europe and Western Offshoots (Australia, Canada, New Zealand, and the

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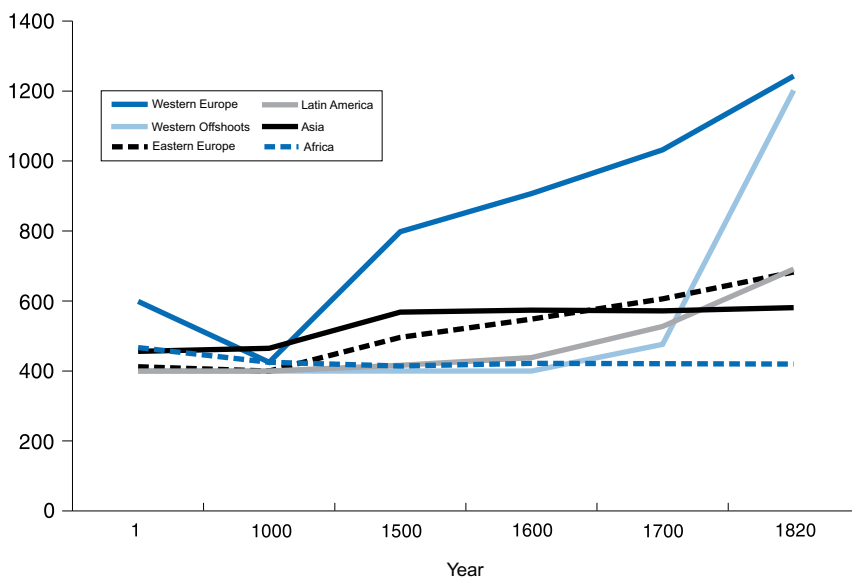
United States), had per capita incomes that increased only by a factor of two to three over a span of 1800 years. This amounts to minuscule growth of only about 0.04 percent per year. By 1820, the richest region (Western Europe) had per capita income about three times that of the poorest region (Africa). But this is nothing like the 30-fold difference we see today between the richest and poorest countries. The story of economic growth before 1800 appears to be one of stagnation in living standards.

The near-zero growth of per capita incomes between 1 AD and 1820 does not mean that there was no technological progress during that time. Productivity-improving inventions such as the stirrup, the heavy plow, and the three-field system of crop rotation were being adopted. However, societies responded to technological advance by increas-

[1] The Organization for Economic Cooperation and Development is a group of 30 countries that share a commitment to democratic government and the market economy. The working paper by Romina Boarini, Asa Johansson, and Marco Mira D'Ercole provides an overview of the literature on wealth and happiness.

FIGURE 1

Per Capita Income 1 AD to 1820 AD

Per Capita Income $1990

Source: Maddison (2006) at http://www.ggdc.net/maddison

these forces roughly cancel each other. Thomas Malthus famously argued that the stability of living standards at a low level of subsistence resulted from the tendency of population to grow whenever living standards rose above a subsistence level. The benefits afforded by steadily improving technology were absorbed in supporting a steadily rising population.

POST-1800 INCOME DISTRIBUTION: THE INDUSTRIAL REVOLUTION AND THE ERA OF MODERN ECONOMIC GROWTH

While the pre-1800 era is marked by relatively little, if any, growth in per capita incomes across countries, the post-1800 era is marked by a dramatic surge in growth for some countries but not others. We see this in Figure 2, which plots income per capita for the same regions as in Figure 1 but includes the period 1820 to 2000. Some regions, such as the West, experience sustained increases in their per capita incomes. Other regions, such as Africa, show virtually no increase in per capita income over this time span. A consequence of this disparity in growth is that the levels of income per capita vary greatly across regions. Indeed, by 2000, the countries labeled Western Offshoots (Canada, the U.S., Australia, and New Zealand) had per capita incomes that averaged about 15 times higher than the per capita income of Africa. The U.S. has a per capita income that is about 30 times higher than that of the poorest countries in Africa.

The central question of economic development is why some countries make the transition to modern growth while others stagnate. Many factors appear to be at work, and the particular set of circumstances, policies, and institutional structure that coincides with the transition to modern growth

ing their populations rather than by accumulating more capital per worker and thus increasing output per worker. In other words, population grew at the same rate as output, so that output per worker, or living standards, stayed nearly constant.[3]

Why was there no growth in per capita income in the pre-1800 period? Before 1800, land was a very important factor of production, since

economies were largely agrarian. However, the quantity of land available for production was to some extent fixed. If the return to adding a worker to a plot of land diminishes as more workers are added, output per worker declines with population growth. However, technological advance is an offsetting factor that makes workers more productive. If these two opposing forces of population growth and technological advance approximately balance each other, output per capita remains roughly constant over time, even though technological progress occurs.[4] It is not a coincidence that

[2] To get a common unit of measurement across countries, Maddison expresses GDP in 1990 Geary-Khamis dollars. Geary-Khamis is an aggregation method in which international prices and purchasing power parity are estimated simultaneously. See the OECD's website http://stats.oecd.org/glossary/detail.asp?ID=5528 and its references for a more detailed description.

[3] For a different point of view, see the book by Esther Boserup, who argues that rising population density drove technological progress.
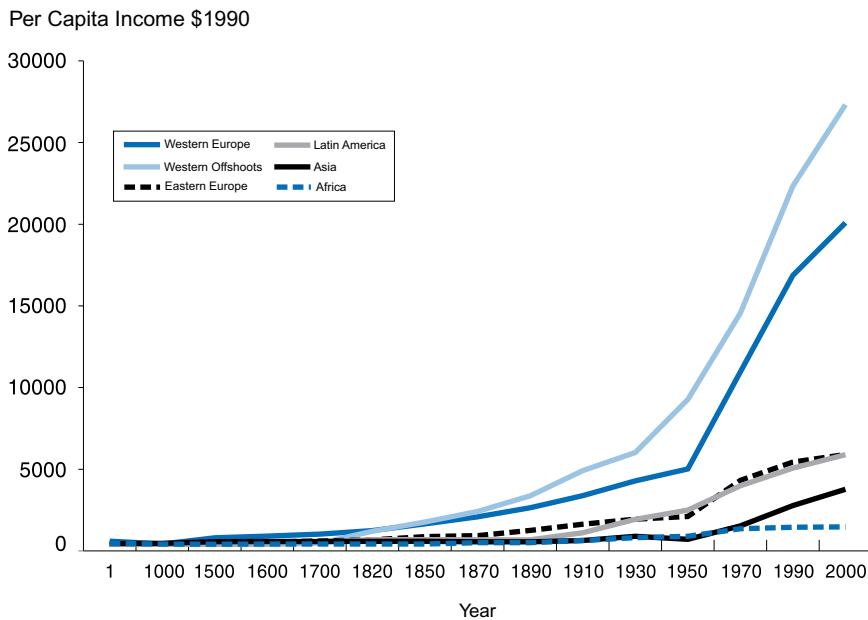
[4] The paper by Gary Hansen and Edward Prescott presents a unified theory of growth that makes an effort to account for the pre-1800 and post-1800 growth experience. Their theory assumes that population increases with consumption at low standard-of-living levels.

Per Capita Income 1 AD to 2000 AD

Per Capita Income $1990

Source: Maddison (2006) at http://www.ggdc.net/maddison

the industrialization process at the same time. Consequently, the world income distribution started to become more unequal as some countries started to grow (at different dates) and others that had not started to industrialize continued to stagnate.

Income inequality across countries largely increased from about 1820 until the latter half of the 20th century as more and more countries began to industrialize. Since 1960, there are good cross-country data that can be used to examine the change in the world income distribution more carefully. Alan Heston, Robert Summers, and Bettina Aten have developed these data in the Penn World Tables. In these tables, these researchers provide national income accounts converted to international prices for 188 countries from 1950 to 2004, assuming purchasing power parity holds.[6] Their data set allows a direct comparison of income across countries because incomes are measured in common units.

Figure 3 plots the distribution of income per capita across countries using the Penn World Table Mark 6.2.[7] The distribution is approximated by a histogram, which shows what proportion of countries fall into a particular category of per capita income levels. In Figure 3, income levels are measured relative to the U.S., so the scale runs from zero to one.[8] Histograms are

varies from country to country. Developing well-defined property rights seems to be an important factor as does developing human capital so that people can implement and take advantage of new technologies.

What we see happening as countries make the transition from stagnation to economic growth is that countries industrialize, technological change allows for increasing productivity, and capital accumulation begins. That is, residents invest in buildings and machines that help produce more future output. Countries that enter this modern growth phase shift from primarily agricultural output to industrial output that is not as land intensive. That is, countries undergo an industrial revolution. A second key observation is that fertility changes, so that improvements in technology

no longer result in matching increases in population. Parents have fewer offspring and invest more resources in their care and development. This demographic transition is a defining feature of the transition to sustained growth for economies.[5]

Great Britain was the first country to enter the industrialization process. The exact date of the Industrial Revolution's beginning is difficult to determine, but many historians place it in the latter half of the 1700s. From Great Britain, it spread to Western Europe and the United States. The onset of the Industrial Revolution led to divergence in per capita incomes across countries, since not all countries began

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[5] The article by Aubhik Khan discusses the relationship between the demographic transition and industrialization in more detail.

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[6] Purchasing power parity is a relative price concept that measures the number of units of country A's currency that are needed in country B to purchase the same quantity of a good or service as one unit of country A's currency will purchase in country A. See the OECD's glossary of statistical terms at http://stats.oecd.org/glossary/index.htm.

[7] The data are available at http://pwt.econ.upenn.edu/.

[8] Some countries have higher per capita income than the U.S. We placed all countries with per capita incomes greater than or equal to the U.S. in the same data category as the U.S.

plotted for three years: 1970, 1985, and 2000. All countries that have data available for each of the three years are included in the charts. Perhaps the most striking observation from the charts is that so many countries have per capita incomes far below that of the U.S. In fact, about 75 percent of countries in the 2000 sample have per capita incomes that are less than half that of the U.S. Furthermore, the distribution has been fairly stable over the 30-year span.

Although there wasn't a large change in the number of poor countries between 1970 and 2000, that doesn't mean that worldwide poverty has not decreased. First, the histograms in Figure 3 assume that each resident of a country gets the same share of real GDP. However, we know that there is income inequality within countries and that this inequality can change through time. Any such change in within-country inequality is not captured by the histograms in Figure 3. Nevertheless, the difference in living standards across countries tends to exceed the within-country differences by most measures. For example, in 1988 the ratio of the per capita income of a country in the richest 10 percent of countries to that of a country in the poorest 10 percent was 20. But for the U.S., the ratio of the permanent income of an individual in the richest 10 percent to that of an individual in the poorest 10 percent was less than four.[9] Second, the histograms in Figure 3 give each country equal weight, despite the fact that some countries have much larger populations than others. So if China, with its massive population, jumps to a new income category in the figure,

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[9] Permanent income is a measure of a wage earner's long-term income that ignores short-term fluctuations in earnings.

FIGURE 3

## World Income Distribution Per Capita Relative to U.S.
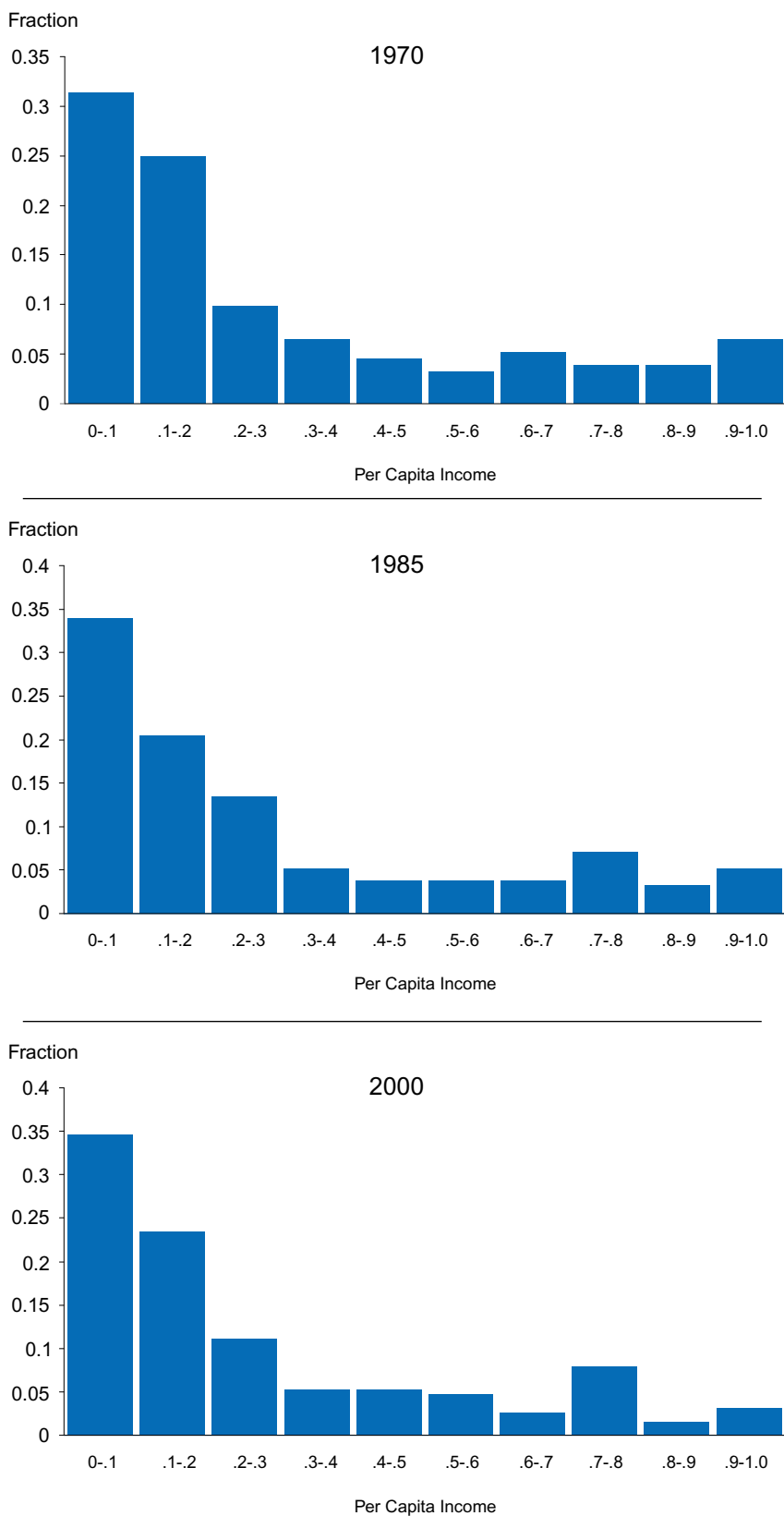
it has the same effect as if Bermuda jumped income categories.[10]

We can partially correct our histograms for country size by multiplying income per capita in each country by that country's share of world population (note, though, that this still does not correct for within-country inequality). The weighted country distributions are shown in Figure 4, and now the picture looks somewhat different. We see that in 1970, ignoring within-country inequality, nearly 60 percent of the world population had a per capita income that was 15 percent or less than that of the U.S. By 2000 there had been a significant shift, in that the 15 percent of U.S. income or less category shrank at the expense of the 15 to 40 percent category. Thus, many fewer people were in the lowest income category compared to 1970. What's happening is that high-population countries like China and India are starting to experience sustained increases in per capita incomes. This evidence suggests that world poverty has been decreasing even though the distribution of country per capita incomes has remained relatively stable.

A SIMPLE MODEL OF THE WORLD INCOME DISTRIBUTION

The evidence presented so far suggests three phases for the dynamics of the world income distribution. The first phase, the pre-1800 period, is characterized by economic stagnation because per capita incomes were not growing. The second phase, from 1800 to the latter half of the 20th century, is characterized by increasing inequality as industrialization diffused through the world's economies. The third phase, from about 1960 to now, was one in which the world income

[10] See the article by Xavier Sala-i-Martin for a thorough discussion of this issue.

FIGURE 4

Population-Weighted World Income Distribution Per Capita Relative to U.S.
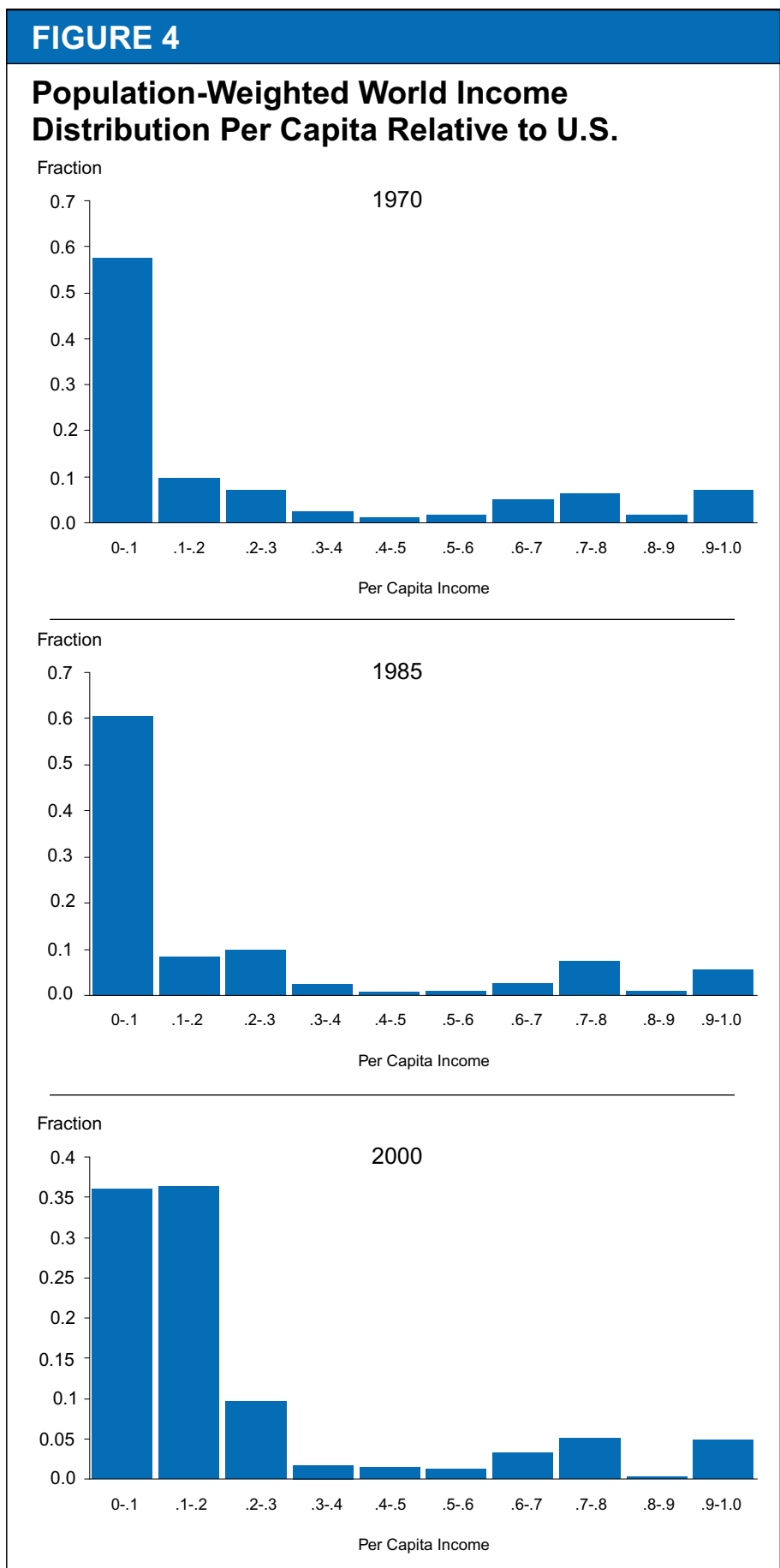
distribution was somewhat more stable.

How should we think about these phases and the recent stability of the distribution? Is the recent period a pause before a return to a further increase in inequality? Is it the shape of things to come, in that things have settled down and we should expect the future to look much like the recent past? Or is the most recent phase merely a transition period that will usher in a period of declining income inequality across countries?

The last conjecture is nicely advocated in a recent paper by Nobel laureate Robert Lucas titled "Some Macroeconomics for the 21st Century." We are going to explore Lucas's reasoning further and, as a byproduct, see that the conjecture about a "pause before a return to increasing inequality" and the conjecture about the "shape of things to come" are somewhat at odds with the long-run world-growth mechanism. However, none of the views can really be proven or disproven based on the existing set of facts, since the truth will be revealed only as the future unfolds.

Lucas uses a simple mechanical model to articulate the view that the last 40 years represent a transition period for the world income distribution. The transition can be thought of as moving from the pre-industrial era to the post-industrial era. The post-industrial era is one in which industrialization has largely diffused throughout the world's economies and ever fewer countries remain stagnant. The model is mechanical in the sense that while it is based in part on an economic interpretation of the facts, there are no choices, policies, or meaningful actions at the model's core.

The model has several key elements. Consider first the concept of the *technology frontier*. The frontier represents the best, most recent technology that countries can use for transforming labor and capital inputs into output. These new technologies represent things like information technology, genetics, advances in medical care, improved organizational methods, and a host of other things that make labor and capital more productive. If we examine the data on per capita incomes for countries over the past 200 years, we could reasonably argue that, on average, the richest countries, those at the technology frontier, increase their real incomes at a pace of about 2 percent per year. If we take this as giving us some information about the pace of technological advance, we can say that the technology frontier grows about 2 percent per year. This represents the maximum long-run growth a country can achieve. The model takes this as given and does not describe an economic mechanism for why the technology frontier grows at 2 percent or how to make it grow faster.

For simplicity, assume that all countries have the same population and that the population does not grow.[11] Also, think of these countries as starting out at some time before the Industrial Revolution, so that there is no growth in real income per capita. The model begins at a time when the world consists of a bunch of poor, stagnant economies that have the same incomes and the same populations. How does growth occur and industrialization diffuse? Lucas uses a racetrack metaphor to describe how the model works.

Imagine all countries lined up in a row like horses at the starting gate of a racetrack. But instead of all gates opening at the same time, they open randomly. When the gate opens, the corresponding country starts to grow. Thus, some economies start to grow at time 1, others at time 2, others at time 3, etc. In any year after the starting period (taken to be 1800), the world economy is composed of countries that have already been growing, those that just started growing, and those still waiting to start growing. The Lucas model does not posit any economic reasons for a country to make the transition to modern growth and so does not offer policy advice to kick start economies into the growth phase of development. Rather, it models the random process by which gates are opened using observations on world income growth since 1800.[12]

The model makes two other key assumptions based on observations of historical growth rates. First, when a country begins to grow, it does not necessarily grow at 2 percent, the rate of growth of the technology frontier. Rather, it grows at 2 percent plus a growth rate determined by the income gap between itself and the richest country. The later a country starts to grow, the larger is the income gap between itself and the leader (which we will take to be the U.S.) and the faster it grows. As a country closes the income gap with the leader, its growth rate begins to slow toward 2 percent. In the long run, a country that is growing does so at 2 percent, the rate of growth of the technology frontier.[13] This modeling behavior is based on observations from countries such as South Korea, Japan, and China, which experienced very high growth rates as they began the industrialization

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[11] The model assumes that all countries are the same size and so makes the same prediction for inequality whether or not countries are weighted by population. In the model, country size does not matter for growth or development or for the inequality consequences of development of large-population economies.

[12] Thus, the model does not explain why the Industrial Revolution started in England and then quickly spread to continental Europe and the United States.

[13] See Lucas's 2000 paper for a detailed description of the model and how it is calibrated.

process. This can happen because these later entrants to the growth club do not have to reinvent all of the advanced technologies they see in countries like the U.S. To some extent they can import advanced technologies and try to copy existing best practices and methods. This allows them to industrialize more rapidly than if they had to develop all the new technologies themselves.
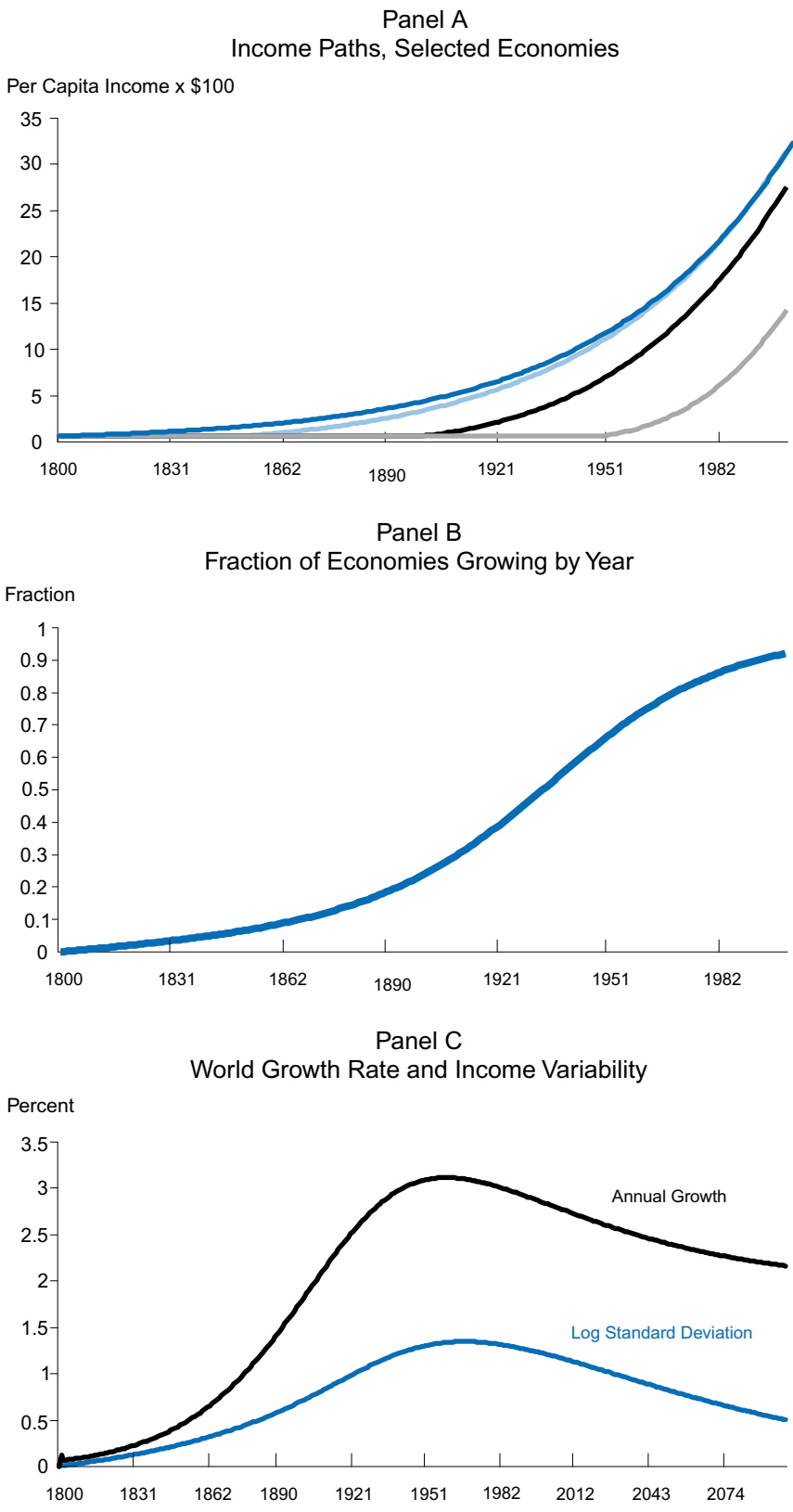
Another key assumption is that the probability that a stagnant country begins to grow in any given period is positively related to the level of income in the rest of the world. The more countries that are growing in the rest of the world, the higher the probability that a stagnant country will start to grow. This is a model of spillovers: The more technology the world acquires — the more prevalent or diffuse it is — the easier it is for a stagnant country to begin taking advantage of it and start the industrialization process.

Figure 5 shows some results from simulating Lucas's basic model, reproducing some figures from his article. Panel A shows how the model behaves for a sample of four countries that start growing at different times: 1800, 1850, 1900, and 1950. The first country that begins to grow (shown in blue) – the leader country – grows at a rate of 2 percent. The countries that begin to grow later (shown in light blue, black, and grey) do so at progressively faster rates initially because their income gap with the leader is wider, the longer they remain in stagnation. Over time, the income per capita in these countries just about catches up with the leader's per capita income. Panel B plots the model's prediction about the fraction of countries that have entered the modern growth phase for the period 1800 to 2000.[14] By 2000,

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[14] The model calibration is the same as in Lucas's 2000 paper.

FIGURE 5

Results from Simulating Lucas Model*

Panel A
Income Paths, Selected Economies

Per Capita Income x $100

Panel B
Fraction of Economies Growing by Year

Fraction

Panel C
World Growth Rate and Income Variability

Percent

Annual Growth

Log Standard Deviation

* Figures recreated by author based on Lucas (2000)

about 90 percent of the world's economies have entered the modern growth phase. Panel C shows the implied world annual average growth rate and a measure of cross-country inequality. The annual average growth rate is simply the average rate of growth of all the economies in the model. The income inequality measure plotted is the cross-country standard deviation of incomes (in logs).

The key figure is Panel C. It shows that the growth of world average annual income peaks at a rate a bit above 3 percent around the 1970s and then begins to decline. Average annual growth can exceed 2 percent (the growth rate of the technology frontier) because countries that start to grow later than 1800 get to grow faster than the leader country in order to close the income gap. The model is set up such that long-run annual growth is 2 percent for all growing countries, so eventually world average annual growth will stabilize at 2 percent when all countries are growing at the same rate as the leader country. The income inequality measure also peaks in the 1970s. It starts at zero, when no country has yet started to grow and all have the same per capita income. It then rises until the 1970s, after which it declines; eventually it will return to zero when all countries are growing at a rate of 2 percent. Thus, the calibrated model predicts that the maximum dispersion in per capita income across countries occurred around 1970, and inequality will subsequently decline as more and more countries begin to experience modern growth and fewer are left in stagnation.

We see then how the model helps us think about the plausibility of the "pause before a return to further inequality" story and the "shape of things to come" story mentioned earlier. The basic force in the model is that industrialization diffuses through-

out the world economy and eventually all countries enter the club of growing economies. What happened in the past guides the model's predictions about what will happen in the future. Eventually all countries get in on the act, and incomes become less and less unequal across countries. In this sense, the stability of the income distribution over the past 40 years or so shouldn't be extrapolated into the future to

> Each country is unique and the particular combination of factors that will push an economy over the threshold to sustained growth varies from country to country.

predict permanent large income differences across countries.

Of course, the basic model is very simple and lacks many features that we expect to influence the growth paths of individual economies and the transition of stagnant economies to growth economies. For example, no business cycles are built into the model: Once countries start to grow, they continue to grow without experiencing recessions. There are no disasters like wars that could have long-lasting effects on growth paths. In addition, the model does not incorporate the demographic transition we spoke of earlier or capital flows across countries. Despite these omissions, the model is basically in accord with the evidence on cross-country income growth since 1800. Importantly, it provides a plausible guide for thinking about the future of the world income distribution, one that is optimistic about the prospects. It may take a long time, but eventually

all countries move from pre-industrial to post-industrial.

POLICY PRESCRIPTIONS

The Lucas model assumes that poor countries will eventually develop the environment necessary for sustained growth in per capita income to begin. It does not offer prescriptions for policymakers on how to make that happen. What can policymakers in poor countries do to push their countries into the sustained-growth phase? This question has generated enormous interest on the part of economists and policymakers. Perhaps the best that can be said is that each country is unique and the particular combination of factors that will push an economy over the threshold to sustained growth varies from country to country. However, rich countries do appear to share some common factors that suggest directions for policymakers in poor countries.

Recent work by Stephen Parente and Edward Prescott examines the question of why some countries are richer than others. They come to the view that cross-country differences in incomes can be traced to the differential knowledge that societies apply to the production of goods and services. It's not that societies differ fundamentally in the knowledge available to them; that knowledge is largely available to all countries by observing the methods and practices of advanced countries, by trading with advanced countries, or by licensing advanced technologies. Rather, Parente and Prescott conclude that poor countries do not fully exploit the existing stock of usable knowledge because poor countries implement policies that constrain work practices and hinder firms' ability to implement more advanced production methods. These barriers are often put in place to protect the vested interests of entrenched groups.

Parente and Prescott reach this conclusion in part because they find that differences in savings rates across countries are unable to account for differences in international incomes. This is so even when they define savings broadly to include intangible capital and human capital. Intangible capital includes things like expenditures allocated to developing and launching new products and expenditures on increasing the efficiency of existing practices. Human capital includes the acquired knowledge that individuals obtain from education and on-the-job training. In Parente and Prescott's reading, differences in savings rates across countries can account for only a small portion of the international differences in incomes we observe.

In a famous 1988 paper, Robert Lucas laid out a theoretical case for the role of human capital in the analysis of growth and development. Subsequent research, including that of Parente and Prescott, failed to find a large role for disparities in human capital in accounting for income differences. However, recent work by Rodolfo Manuelli and Ananth Seshadri and by Andres Erosa, Tatyana Koreshkova, and Diego Restuccia re-evaluates the role that differences in human capital across countries play in accounting for income differences. Manuelli and Seshadri argue that when one measures human capital correctly, paying careful attention to differences in the quality of human capital across countries, it turns out that differences in human capital play a large role in accounting for income disparities. Indeed, in some versions of their model, the differences in the stock of usable knowledge across countries that was emphasized by Parente and Prescott play little, if any, role in accounting for differences in income across countries; the difference is largely accounted for by accumulated factors: labor and capital broadly defined to include human capital. In Manuelli and Seshadri's model, policymakers would do well to find ways to facilitate human capital accumulation among the residents of poor countries.

Erosa, Koreshkova, and Restuccia similarly emphasize the role of human capital in accounting for cross-country income differences. But their model differs from that of Manuelli and Seshadri in important details, such as allowing wage growth over people's lifetimes to be influenced by investment in physical capital and by technological progress. They argue that technology is strongly amplified by the stock of human capital. Their finding of significant differences in the average level of human capital across countries then goes a long way toward explaining cross-country differences in per capita incomes.

The somewhat opposing findings of Parente and Prescott vs. those of Manuelli and Seshadri and Erosa, Koreshkova, and Restuccia highlight some of the difficulties researchers face in studying cross-country income differences. The data on growth and development experiences of countries do not point to an obvious, unique recipe for making poor countries rich. The development process is the outcome of a complex mixture of policies and institutions. Securing property rights and creating a level playing field are likely to help individuals and firms acquire the capital and technology required to push an economy onto a sustainable growth path. **BR**

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